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What Pressure Is Necessary for Potato Spraying?

WM. H. MARTIN,

Agricultural Experiment Station, New Brunswick, N. J.

Potato spraying is no longer under trial in New Jersey. The Experiment Station has conducted tests since 1913 to determine the value of this practice under New Jersey conditions. During this period, late blight was a factor in only three of the tests, despite this fact increased yields have followed with but one or two exceptions. In some cases increases amounting to 90 bushels per acre have resulted and the average increase for the 17 year period over which the work was conducted is approximately 40 bushels per acre.

During the past four or five years, the increase from spraying potatoes with Bordeaux mixture in New Jersey has resulted, for the most part, from the control of flea beetles and leafhoppers. Late blight has not been present and early blight has been of very minor importance. In the past it was generally held that potato spraying paid only where these two diseases were present. We know now that where flea beetles and particularly leafhoppers are present satisfactory results will follow spraying.

In New Jersey, there is no longer any question concerning the value of spraying potatoes with Bordeaux mixture. The results of our tests coupled with the experiences of the practical grower have demonstrated the value of this practice beyond any question of doubt. We are likewise convinced that satisfactory results will follow the use of a Bordeaux mixture made from a chemical hydrated lime. The bother of slaking stone lime has been eliminated and as a consequence the preparation of Bordeaux

mixture has been greatly simplified without reducing in any way the efficiency of the finished product.

For the past few years, a number of the New Jersey growers have raised a question concerning the pressure necessary to employ in spraying potatoes. This is important for, if pressures greater than 300 pounds are necessary, it is obvious that an engine driven sprayer will have to be used. If, on the other hand, a pressure of from 200 to 250 pounds is satisfactory, the cost will be reduced due to the fact that a traction sprayer may be used for the operation.

In order to answer this question, spray tests have been conducted the past two years with the Irish Cobbler variety. In these tests, an engine driven sprayer was used and a 5-7-50 Bordeaux mixture, prepared with hydrated lime, was applied at pressures of 150, 250, and 350 pounds. In 1928, the various treatments with their checks, sprayed with calcium arsenate, were replicated eight times and in 1929, seven times. In the former year, all plots received five applications, while, in 1929, six applications were made.

In 1928, flea beetles were observed to be present to some extent on June 19th, but did not become severe until later in the season. By July 18th, the damage they had done was clearly apparent and a number of leaves were collected from each of the various plots to determine the average number of flea beetle punctures per leaf. In 1929, flea beetles made their appearance somewhat earlier and by July 1st, the plants of the check plots were covered. On July 8th, leaf samples were taken and counts made. The results of the two years counts are shown in Table 1.

In 1928, leafhoppers first appeared on June 27th and soon were present in large numbers. At first their presence resulted only in a lighter green color in the leaves in the check rows, but by July 18th, a large part of these leaves had been killed. In 1929, leafhoppers again made their appearance the last week in June and, by July 8th, had caused serious damage. The results of the counts made on the number of dead leaves, resulting from the presence of leafhoppers is shown in Table 1.

It will be seen that all of the Bordeaux treatments gave a marked reduction in the number of flea beetle punctures per leaf as well as in the number of dead leaves from leafhoppers. In this connection, it should be recalled that in 1928, the check plots received four and in 1929, three applications of calcium arsenate at the rate of 5 pounds of the powdered form to 100 gallons. It is clear from this that an arsenical has but little value in the control of either these insects. It is clear also that Bordeaux mixture will control the leafhopper without the addition of nicotine sulfate. The use of the latter material would result in

TABLE 1. Influence of Spray Pressure On Leafhopper and Flea Beetle Control.

Treatment	Flea Beetle Punctures Ave. per Leaf			% Dead Leaves from Leafhoppers		
	1928 July 18	1929 July 8	Ave.	1928 July 18	1929 July 8	Ave.
Check	205.2	178.2	191.7	76.1	48.0	62.0
150 lbs.	87.4	27.4	57.4	8.3	5.0	6.6
250 lbs.	73.6	31.0	52.3	7.6	4.8	6.2
350 lbs.	99.7	33.0	66.3	11.4	5.2	8.3

a marked increase in the cost of the spray material and, in the light of the results obtained here and elsewhere, its use for the control of the potato leafhopper is unnecessary.

In examining the influence of the different pressures, it will be seen that but little difference in control of these two insects followed the use of the different pressures. It will be seen also that the control following 350 pounds pressure was not so good as that following the use of 150 and 250 pounds. These differences are not great, however, so that we must conclude from the data at hand that as good results in the control of the leafhopper and flea beetle will follow the use of 150 pounds pressure as will result from the higher pressures.

The various plots included in these tests were harvested on August 28th and August 19th, in 1928 and 1929 respectively. The results of the harvest are presented in Table II.

TABLE II. Influence of Spray Pressure On Yield.

	Yield per Acre, Bushels		
	1928	1929	Ave.
Check	294.0	228.4	261.2
150 lbs. pressure	360.0	268.1	314.0
250 lbs. pressure	362.2	284.7	232.4
350 lbs. pressure	365.3	286.2	325.7

In 1928, the average yield increase of all plots sprayed with Bordeaux mixture over those sprayed with calcium arsenate alone was 68.5 bushels per acre. In this year the yields increased slightly as the pressure was increased, however, the difference

between the 150 and 350 pounds pressures was only 5.3 bushels per acre.

In 1929, the average yield of all plots sprayed with Bordeaux mixture was 279.7 bushels and of the check plots 228.4 bushels, an increase of 51.3 bushels in favor of the Bordeaux treatment. As the pressure was increased there was an apparent increase in yield, the 250 and 350 pound pressures showing average yield increases of 16.6 and 18.1 bushels per acre respectively over the plots sprayed with 150 pounds pressure. It is clear that the difference of 1.5 bushels between the 250 and 350 pound pressures is of little significance. It should be said also that the odds are only 3 to 1 that the yield difference between the 150 and 250 pounds pressures is significant.

In considering the average of the two years, it will be seen that as the pressures increased the yields increased. Between the 150 and 250 pounds there was a difference of 9.4 bushels, while between the 250 and 350 pounds the difference was only 2.3 bushels per acre. It is apparent that for the conditions under which these experiments were conducted and particularly in the control of flea beetles and leafhoppers, extremely high pressures were unnecessary. From the results here reported we are led to believe that a pressure from 200 to 250 pounds is ample where these insects are to be controlled. From results secured in previous years in the control of early and late blight, we believe it to be necessary to have pressures higher than those indicated above. We are convinced, as the result of these tests and an examination of many sprayed fields, that failure to obtain results from spraying is very often due to the improper adjustment of the nozzles rather than to the pressure employed. Where the nozzles are so arranged that the leaves are thoroughly covered with a film of Bordeaux mixture, good results will follow.

SUMMARY

Potato spraying experiments in New Jersey, conducted for 17 years, have demonstrated that this practice pays.

Bordeaux mixtures made from a high grade chemical hydrated lime will give as good results as a Bordeaux mixture made from stone lime.

Calcium arsenate will not control the flea beetle or the leafhopper. On the other hand, the injury from both of these insects and particularly the latter, will be greatly reduced by spraying with Bordeaux mixture.

Increased yields followed applications of Bordeaux mixture applied at 150, 250, and 350 pounds pressure. While the yields increased with the pressure the difference between 250 and 350 pounds was slight and it is believed that a pressure in excess of 250 pounds is unnecessary. With 200-250 pounds pressure and proper adjustment of the boom and nozzles, satisfactory results will follow.

Factors Affecting the Cost and Yield of Potatoes on Some New York Farms

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For a number of years, farmers in various parts of New York State have been cooperating with the Department of Agricultural Economics and Farm Management at Cornell University in keeping a complete account of all their farm operations. These men take an annual inventory and keep a record of all labor as well as receipts and expenses. All enterprises on any one farm are charged with labor and equipment, use of land and buildings, etc., at the actual cost on that farm. This discussion is based on data from 126 potato accounts included in these books. It covers a period of five years, (1924 to 1928). In this five-year period, there have been two years (1924 and 1928) in which returns on potatoes were very low; two years (1925 and 1926) in which returns were high; and one year (1927) in which returns were fair.

The cost account cooperators who contributed the information for this study are better than average farmers, both as to size of business and financial success. Their farms, however, are not all located in the intensive potato areas of the State. On a number of these farms, the growing of potatoes is a minor enterprise. Consequently, the potato accounts come much nearer representing average conditions than the farms themselves do.

In order to show the typical practices of the growers, all results discussed in this study were obtained by simple averages. For example, the average yield of 129 bushels per acre is not the average yield obtained from so many acres, but rather the average yield obtained by so many growers, each grower counting one. This same method of analysis is applied to all factors.

The average cost of growing an acre of potatoes for the five-year period (1924-1928) was about $87 (table 1). With an average yield of 129 bushels per acre, this makes a growing cost per bushel of 67c. The average acreage per grower was 10.7. Of the growing costs, labor and equipment accounted for nearly two-fifths and seed for one-quarter. Fertilizer and manure represented nearly another quarter of the growing expense.

TABLE 1. Cost of Growing and Harvesting an Acre of Potatoes. 126 Accounts (1924-1928).

	Cost Per Acre	Per Cent
GROWING—		
Labor and Equipment	$33.77	39
Seed (15.9 bu.)	20.77	24
Manure	10.42	12
Fertilizer (558 lbs.)	8.53	10
Land	6.25	7
Spray and Dust	4.11	5
All other costs	2.87	3
Total	$86.72	100
HARVESTING AND STORING—		
Labor and Equipment	$22.25	87
All other costs	3.19	13
Total	$25.44	100

Average acreage per grower—10.7. Growing cost per bu.—67c.
Average yield per acre—129 bu. Harvesting cost per bu.—20c.

The average cost of harvesting and storing potatoes was $25 an acre, or 20c per bushel. About 87 per cent of this cost was labor and equipment. Where potatoes were sold directly from the field, selling costs were included in the cost of harvesting and storing.

There was considerable variation in the yields, costs, and returns obtained by the different growers (table 2). There were 33 accounts with an average yield of only a little over 50 bushels per acre. The total cost per acre in this group was over $100, making the cost per bushel $1.87. It cost these growers on the average, 29c an hour for the privilege of producing potatoes.

The next group received an average yield of about 100 bushels per acre, and with an additional cost per acre of only $6 lowered their cost per bushel to $1.04 and raised the return for their labor to 37c an hour.

The highest yielding group, with an average of 238 bushels per acre, lowered their costs to 66c per bushel and received an average of 92c an hour for their labor. In general, it may be concluded that increased yields more than compensate for

the increased costs per acre, resulting in lower costs per bushel and greater returns.

There are many factors which are working together to increase the yield of potatoes (table 3.) Those growers who

TABLE 2. Yields, Costs and Returns—126 Potato Accounts (1924-28)

	Yield—Bushels Per Acre			
	Over 80	80-139	140-199	200 & over
Number of accounts	33	44	24	25
Yield (bushels per acre)	54	103	170	238
Acres per farm	6.5	10.1	14.4	13.6
Total cost per acre	$101.00	$107.00	$126.00	$158.00
Total cost per bushel	1.87	1.04	.74	.66
Price per bushel	.92	.99	.84	.87
Return per hour of man labor	—$.29	$.37	$.60	$.92

spray and dust the most have the larger acreages. They also use more fertilizer, plant more seed to the acre, use better seed, and treat it before planting. There is a decided increase in yield as the result of these combined practices. In order to get an indication as to the importance of each practice, it was necessary to divide the growers into two groups, namely, those spraying and dusting less than the average, and those spraying and dusting more than the average.

The use of fertilizer has long been accepted as an important factor for increasing yields. However, the application of considerable additional fertilizer by those growers using very little spray and dust gave them no material increase in yield (table 4). When this same increase in fertilizer was made by those growers who did spray and dust, there was an increase from 134 bushels per acre to 177 bushels. As there was very little difference in the other factors affecting yield, between the group using little fertilizer and the group using considerable, this increase in yield may be attributed primarily to the fertilizer.

An increase in the bushels of seed planted per acre gave no increase in yield to those growers who sprayed and dusted less than the average (table 5). Practically the same increase

TABLE 3. Spray and Dust Yield—126 Potato Occounts (1924-28)

	Spray and Dust Material Per Acre			
	None	Under $4	$4-$6.99	$7 and over
Number of accounts	19	47	33	27
Spray and dust	0	$1.79	$4.91	$10.07
Acres per farm	6.3	9.5	12.5	13.4
Fertilizer (pounds)	244	431	685	846
Price of seed per bu.	$.93	$1.20	$1.42	$1.54
Bushels of seed	14.9	15.1	16.7	17.1
Per cent treating seed	11	32	79	63
Yield (bushel)	79	107	147	184

in bushels of seed planted per acre by those growers who also sprayed considerably showed an increase from 148 bushels per acre to 174 bushels. As some of the other factors also increased slightly along with bushels of seed planted per acre, not all of the increase in yield can be attributed to the quantity of seed.

TABLE 4. Fertilizer and Yield—126 Potato Accounts (1924-28)

	Under $4 of spray and dust material per acre		$4 and over of spray and dust material per acre	
	Under 500 lbs. of fertilizer per acre	500 lbs. and over of fertilizer per acre	Under 500 lbs. of fertilizer per acre	500 lbs. and over of fertilizer per acre
Number of accounts	45	21	19	41
Spray and dust	$1.20	$1.43	$5.74	$7.93
Fertilizer (pounds)	187	784	295	972
Bushels of seed	14.6	16.2	16.3	17.1
Price of seed per bu.	$1.10	$1.18	$1.41	$1.51
Per cent treating seed	27	24	74	71
Yield (bushels)	96	104	134	177

TABLE 5. Bushels of Seed and Yield—126 Potato Accounts (1924-28)

	Under $4 of spray and dust material per acre		$4 and over of spray and dust material per acre	
	Under 16 bu. of seed per acre	16 bu. and over of seed per acre	Under 16 bu. of seed per acre	16 bu. and over of seed per acre
Number of accounts	41	25	24	36
Spray and dust	$1.24	$1.32	$6.29	$7.86
Bushels of seed	12.6	19.1	13.2	19.3
Price of seed per bu.	$1.16	$1.09	$1.57	$1.44
Per cent treating seed	24	28	62	78
Fertilizer (pounds)	301	502	588	870
Yield (bushels)	100	96	148	174

TABLE 6. Price of Seed Per Bushel and Yield—126 Potato Accounts (1924-28)

	Under $4 of spray and dust material per acre		$4 and over of spray and dust material per acre	
	Price of seed under $1.30 per bu.	Price of seed $1.30 and over per bu.	Price of seed under $1.30 per bu.	Price of seed $1.30 and over per bu.
Number of accounts	48	18	24	36
Spray and dust	$1.08	$1.78	$7.08	$7.33
Price of seed per bu.	$.89	$1.79	$.96	$1.84
Bushels of seed	15.2	14.6	17.5	16.5
Per cent treating seed	25	28	67	75
Fertilizer (pounds)	350	448	683	807
Yield (bushels)	99	98	152	171

An increase in the quality of seed, which is indicated by the price per bushel, gave no increase in yield to those growers spraying and dusting less than the average (Table 6). An increase from 152 bushels to 171 bushels was obtained by those growers using more spray and dust than the average, when they planted seed of better quality.

Those growers treating seed, who did not follow it up with sufficient spraying and dusting recieved no increase in yield (Table 7). The increase from 128 bushels to 178 bushels per acre for the growers who did spray and dust is due partly to the treating and partly to the quantity and quality of seed.

TABLE 7. Treating Seed and Yield

	Under $4 of spray and dust material per acre		$4 and over of spray and dust material per acre	
	Not treating	Treating	Not treating	Treating
Number of accounts	49	17	17	43
Spray and dust	$1.02	$2.00	$8.12	$6.88
Fertilizer (pounds)	353	445	733	767
Bushels of seed	15.1	15.1	15.2	17.5
Price seed per bushel	$1.12	$1.16	$1.29	$1.54
Yield (bushels)	99	97	128	178

In this discussion, having shown that higher yields mean greater returns, I have attempted to point out the more important factors affecting yield, and to indicate the degree to which the yield is affected by these factors. The factors are: spray or dust, fertilizer, bushels of seed planted per acre, price of seed per bushel, and the treating of seed. It is evident that the most important problem is to successfully combat disease. This can only be done by the application of spray or dust. Unless a healthy plant is maintained, the other factors do not have an opportunity to prove their worth. To a number of growers who did not spray or dust properly, an increase in the application of fertilizer, and the use of more and better seed, brought lower returns because these increased costs did not result in increased yields. In general it may be concluded, that, in order to grow potatoes profitably in New York State, proper fertilization of the soil and care in the selection and preparation of seed must be accompanied by thorough spraying or dusting throughout the season. Over a period of years, the growers practicing these methods have received excellent returns for their labor.

Cultivating and Fertilizing Potatoes

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The problem of cultivating and fertilizing potatoes can best be considered in connection with the other factors which govern the production and marketing of the potato crop, and are very often greatly modified by these other factors.

The business of producing and marketing potatoes in any state or province is governed by the same economic laws that govern every other business. Any profitable business expands, as for example the movies, automobile and the radio. Any unprofitable business contracts, as for example the top-buggy and the windmill. Maine had only one potato crop as large as 10,000,000 bushels before 1900, this year, 47,644,000. Idaho in 1907 grew 13,000 acres, this year 102,000. New York state grew 441,000 acres in 1907, only 270,000 this year, although in one section of the state, Long Island, production has greatly increased in that time.

Two entirely different sets of conditions govern potato production and marketing. The first set governs the cost, and includes climate, soils, fertilizers, seed, varieties, and the costs of tillage, spraying, harvesting and marketing. The second set governs the market price the grower will receive for his finished product.

Potato production in the United States is divided into two great types, that for sale in nearby markets by wagon or truck, and that for sale by railroad or steamer to distant markets. The carlot sections have immensely increased in importance since 1900. They are those in which the cost of production per bushel is low enough to allow the payment of freight costs to distant markets and still sell in competition with local trucked in stock. In many cases the carlot areas are made up of new lands which have come into heavy production in recent years. The early crop of the southern states is nearly all shipped by rail to distant cities. The late crop carlot sections include Maine, parts of New York, Pennsylvania and Michigan, most of Wisconsin and Minnesota, and nearly all the late crop states further west.

The trucking area includes southern New England, most of New York, Pennsylvania and Michigan and particularly the Corn Belt states from Ohio to Iowa. Across the southern side of this area summer heat is often too great for the potato plant to do its best and growers must often adopt different methods

than are successfully used in the sections further north where cooler summers are more favorable to the potato plant.

The price of potatoes in any consuming city in the trucking or deficiency area is set by the cost of buying them in the often distant carlot of surplus sections, plus cost of freight to the consuming city and of distribution there. In any trucking section the quantity of potatoes produced must be less than the local demand. Whenever, as in Pennsylvania and Iowa in 1928, the local production is so large that part can only be sold in distant city markets in competition with the carlot area, the price for the trucked potatoes falls to the level of the price to growers in the other carlot areas. Because the potato grower in the trucking area can normally get a price considerably higher than can the growers of the carlot area, it is often profitable to use expensive methods of cultivation and fertilization.

Compared with other farm crops, such as corn, the potato plant has a weak and tender root system. The roots are unable to penetrate well into heavy soils, which explains why potatoes seldom do well on clays. The potato plant, particularly at certain stages of its growth cannot stand great heat in the soil. The southern states avoid this trouble by either planting in the winter in order to mature early varieties before the extreme heat of summer, or else they plant in July and make most of the growth in the cool fall months. Although the potato plant can stand considerable drouth at times, it needs much water to produce crops of any size. Because the cash return per acre from potatoes is higher than that of most of the standard farm crops as corn, wheat, etc., the grower is justified in using cultivating and fertilizing methods that would be unprofitable with the others.

These general principles greatly change fertilizing and cultivation methods under different conditions. One section producing early potatoes will use a light, sandy soil because it warms up early in spring, will use an early variety, will plant in high ridges to warm the soil quicker and fertilize very heavily because the soil fertility becomes but slowly available in cold weather. Another section within a few hundred miles may produce main crop potatoes with a variety having a long life, will use much less fertilizer, depending on the soil fertility unloosed by the heat of the summer, and will plant on soils often very heavy. The first section sprays the crop very little, because long life is even undesirable in an early crop. The second sprays with extreme thoroughness in order to carry the crop through the heat of the summer to the cool weather of fall. Each section is using the methods which experience has shown to be most profitable under its local condition of soil, climate and markets.

The rotation of crops is an essential part of crop fertilization. Because of its need of a loose, mellow soil, of abundant fertility, and of a soil retentive of soil moisture, those crops which leave the soil well filled with organic matter are best for rotation with the potato. The different legumes, the clovers, alfalfa, sweet clover and soy beans are favorites in different sections. Selection of the particular one to be used depends on how well it succeeds under local conditions. Because the money value of potatoes per acre is considerably higher than that of most farm crops and because of the high cost of labor and machinery, there is an increasing tendency to plow under the whole of the legume crop preceding potatoes rather than to harvest it for feeding or sale and only leaving the roots and sod for the use of the potatoes.

The general principle that potatoes need a loose and mellow soil with plenty of soil moisture governs preparation before planting. Whether fall or spring plowing or both are used, the great objective is to use the tools and methods which put the soil in this condition, the choice of tools and methods depending on local conditions. After planting, the essential principles of cultivation are to prevent weed growth and to keep the soil loose and mellow as long as possible. For many years it was strongly believed that the principal reason for cultivation was to maintain a surface mulch of mellow soil which would operate to lessen loss of soil moisture through evaporation. It is now believed that cultivation is more important for prevention of weeds than for this purpose.

Two classes of weeds demand different methods of control. Those having perennial rootstocks such as the Canada thistle, morning-glory, quack-grass and hairy smartweed can only be destroyed by exhausting the material in the underground parts. This is most difficult, if not impossible, to do during the growing season of the potato plant. I have found that with quack-grass fall plowing is absolutely necessary under central New York conditions. As soon as the soil can be worked in the spring deep and thorough disking is begun, and repeated at intervals short enough to prevent the quack-grass from getting a real start. By these methods the quack-grass plants can be repeatedly forced to start new shoots and so reduce the stored plant food in the rootstocks. Just before planting, about June first, the soil is again plowed about ten inches deep, which leaves it very loose and mellow. Frequent use of the cultivator further discourages the quack-grass until the fast growing vines shade the soil well. Only in very wet seasons does the quack live through to injure the yield. This treatment has also

eliminated Canada thistle, and reduced morning glory to a small amount of damage.

The second great class of weeds is that of the annuals which grow from seeds. Any weed can be killed by tearing it loose from the soil and exposing to the sun long enough. The great principle in fighting annual weeds is to destroy them when they are weakest. This is just after the growing shoot has partly exhausted the store of plant food in the seed, and before it has had time to form new growth above the soil from which to manufacture new plant food. Thorough tillage early in the spring before planting does so kill part of the sprouting weeds, but it is unfortunate that many of our worst weeds do not sprout till warmer weather.

After planting the grower has two problems instead of one. He still has to keep stirring the soil to kill weeds, but he now has to remember that the same tools that are so efficient to kill weeds will damage or destroy the growing and tender potato plants unless great care is used. Expensive methods of mulching by means of straw or of paper can be used as a substitute for tillage for control of weeds. Any system of tillage must be a compromise between extreme care to kill weeds and extreme care to prevent damage to potato plants.

The tools and the methods must in every section be those adapted to local conditions. Personally, I cultivate between the rows as soon as weeds start, and before the potato plants appear. Because my soil is deep and without a hardpan so often found, I level down the rows just before the plants appear with a leveling tool built for that purpose. It is essentialy a 2 by 10 plank six feet long set on edge and drawn through the soil by two horses or a tractor. It kills the weeds very well without damage to the potato sprouts. After the plants are through the ground standard cultivators and weeders are used after each rain or at intervals of about a week. Early cultivation is deep, later ones very shallow The six-row cultivator made up of a Farmall tractor and two standard two-row cultivators is very fast and very efficient. It is plain that these methods might be worthless under different conditions, and are only given here as an example of how one set of conditions is met.

The most important part of cultivation is to get weeds controlled so early that it is possible to stop before injury to the growing potato crop. Careful experiments have proved that it is far easier to reduce yields by cultivation too late than most growers can believe. Three tests are used by experienced growers. In New York state, at least, the appearance of either blossoms or of small tubers is a warning that the plants are too large to be cultivated more. Both are reproductive pro-

cesses that are exhausting to the plant. The third sign is in the potato roots. In the early life of the plants the roots have a tendency to drop downward in the soil. At or just before blossoming a new type of roots sometimes called brace roots begins to extend in every direction just under the surface of the soil. A good test for the appearance of this type of roots is to wash out the sides of the hill with water. Destruction of these roots by late cultivation can cut the yield by one half. It is true than in some season dry weather in the early life of the plants prevents the weed seeds from sprouting. If heavy rains come when the plants are a foot or more high the grower may have the unpleasant choice of either killing the weeds by cultivation that damages the plants, or of letting the plants be damaged or smothered by the weeds.

The problem of potato crop fertilization is that of the net return or the increased yield over the increased cost—whether the grower shall use farm manures, commercial fertilizers or rotation crops plowed under to increase the yield is a question to be answered under each separate set of conditions by the profit to be obtained from the use of either. In any case considerable knowledge of local conditions is needed to determine the relative value of nitrogen, phosphorus and potassium in the commercial fertilizers, or of the farm manure or the rotation crop.

The general principle holds true that as the potato is a relatively tender plant compared to corn and as the acre value is high it pays better than other farm crops for high fertilization. Even the seed potatoes used may be considered to be one form of indirect fertilization. It is well known that the crop yield increases when the amount of seed used per acre is increased. Many growers take advantage of this fact by using heavier seed in springs when seed is low in price. Then when seed is high in price the seed is reduced in amount and more fertilizer is used.

The use of commercial fertilizers on potatoes has increased very fast in the eastern part of the United States in the last thirty years. From 2,000 to 2,500 pounds per acre is the standard application over very large areas from Maine southward along the Atlantic coast. Going west the quantity of fertilizer used per acre gradually diminishes until the point is reached where it is no longer profitable. Certified seed growers often find fertilizers pay better than do growers of table stock because of the higher price of their product. In the past few years the use of concentrated fertilizers has increased very fast and in time will greatly increase the use of commercial fertilizers in sections where they were formerly unprofitable because of the high cost of transportation.

Cost of Growing Potatoes in Ohio in 1927, 1928 and 1929

GUY W. MILLER,
Department of Rural Economics, Ohio State University,
Columbus, Ohio.

During the last three years potato growers in Ohio who have been enrolled in the "400 Bushel Potato Club" have submitted records of the cost of growing their crop to Mr. Tussing, Department of Horticulture. Other farmers have been keeping potato cost records in cooperation with the Department of Rural Economics, Ohio State University. These records have all been grouped by years and summarized. (1) Effort has been made to keep the material on a comparable basis in different years and on different farms. Lower rates and land values vary somewhat according to the nearness to large cities but the methods used have been the same.

Attention is called to the fact that the records include only the cost of growing and harvesting. Grading and marketing costs were not available as many growers sold direct from the fields or barn without grading their product. Also it should be noted that the growers who submitted records are above the average for the state of Ohio.

Table I shows a high yield and cost per acre in 1927 compared with 1928 or 1929. The fact that costs only on the best acre were submitted is partly responsible for this. In some cases this acre was selected from an area where certified seed was used and best fertility practices followed. Hours of labor in harvesting were also increased by a larger yield. The increased yield per acre in 1927 tended to bring the costs per bushel down from the level of 1928 and 1929.

COSTS IN 1928 AND 1929

The average yield per acre in these two groups was practically the same. Comparisons can be made with the important factor of yield per acre practically eliminated except for variation in weather conditions between the two years. Some items are of interest in this comparison.

1. The cost per acre was $11.33 less in 1929.
2. Cost per bushel dropped 4.7 cents.
3. A decrease in seed cost of $13.86 per acre was responsible for the lowering production cost. The number of bushels used per acre increased mainly due to cheap seed in 1929.
4. Records show less pounds of fertilizer used in 1929 but of a higher analysis.

TABLE I. Comparative Per Acre Costs of Growing Ohio Potatoes 1927, 1928 and 1929.

YEAR	1927	1928	1929
Number of growers	36	72	23
Number of acres (2)	36	762	156
Ave. yield per acre, bu. (2)	322.4	239.5	239.8
Ave. cost per acre	$142.15	$130.95	$119.62
Ave. cost per bu., cts. (2)	44.1	54.6	49.9
Seed cost	18 bu. $40.34	20.8 bu. $38.46	22.5 bu. $24.60
Manure cost	9.3 tons 10.37	7.7 tons 7.87	7.1 tons 7.14
Fertilizer cost	838 lbs. 11.40	928 lbs. 13.12	699 lbs. 13.00
Green manure cost	4.83	5.22	5.84
Man labor	82.2 Hrs. $32.37	71.7 Hrs. $26.97	79.3 Hrs. $28.09
Horse labor	73.8 Hrs. 14.33	61.7 Hrs. 11.50	79.8 Hrs. 13.56
Tractor labor	2.8 Hrs. 4.23	3.2 Hrs. 4.06	1.7 Hrs. 2.53
Spraying cost (3)	6 times $ 9.45	8 times $10.80	6.4 times $10.83
Use of machinery	4.42	3.74	4.69
Land charge	10.41	9.21	9.34

(1) Explanation of method is given on last page of paper.
(2) Records in 1927 included costs only on the best acre.
(3) Spraying cost includes materials and depreciation of sprayer.

5. There was little apparent change in total fertility, spraying, machinery or land costs between the two years.

6. The per hour charge for man and horse labor decided upon by the growers averaged slightly less in 1929.

7. Costs per bushel on individual farms varied from 32 cents to $2.34 in 1928 and from 23 cents to $1.18 in 1929.

While the groups do not contain the same men in all three years, they are widely enough scattered over the potato area of the state to get the prevailing practices. Eighteen growers of the 1927 group were represented in the 1928 group. Ten of the 23 in 1929 were also in the 1928 group. Four growers submitted records all three years.

The percentage of the total cost taken by the various items is of interest.

TABLE II. Percentage Division of Costs in Growing Potatoes.

	1927		1928		1929	
	Cost	Percent of Total	Cost	Percent of Total	Cost	Percent of Total
Seed	$ 40.34	28.3%	$ 38.46	29.4%	$ 24.60	20.6%
Fertility	26.60	18.9	26.21	20.0	25.98	21.8
Labor	50.93	35.8	42.53	32.5	44.18	36.9
Spraying	9.45	6.6	10.80	8.8	10.83	9.0
Use of Machinery	4.42	3.1	3.74	2.9	4.69	3.9
Use of Land	10.41	7.2	9.21	7.0	9.34	7.8
Total	$142.15	100.0%	$130.95	100.0%	$119.62	100.0%

Seed, fertility, and labor account for approximately 80 per cent of the total cost. Labor amounted to about one-third of the total growing cost. Spraying cost including depreciation on the sprayer amounted to less than 10 per cent. Any small increase in spraying cost that increases yields is money well spent. Seed cost is the most variable item and one on which most chance is taken.

Twenty-nine growers in Cuyahoga county near the city of Cleveland had the following distribution of growing costs in 1923. Seed 15.3 per cent, fertility 24.6 per cent, labor 41.5 per cent, spraying 3.3 per cent, use of machinery 4.0 per cent, and use of land 11.3 per cent.

It is generally recognized that the yield per acre is the most important factor in determining the cost of growing a bushel of potatoes. In Table III the 72 records of 1928 are distributed in groups according to yield per acre.

Table III indicates the costs per acre showed less variation than costs per bushel. Yield per acre was the most important factor affecting the cost per bushel.

The cost per bushel was $1.29 greater in the low production group than in the group with yields of 350 bushels or over.

The number of times sprayed decreased as yields decreased.

The fertility cost was greatest in the high production group.

ANALYSIS OF 72 RECORDS IN 1928

Thirty-six farms had yields above 225 bushels per acre, the average being 304 bushels. Their cost per acre was $135.49 and per bushel 44.5 cents.

Thirty-six farms with yields of 225 or under had an average yield of 165 bushels per acre. Their cost per acre was $125.74 and per bushel 76 cents.

TABLE III. Variation In Costs of Growing An Acre and Bushel of Potatoes in Ohio, 1928

Range in Yield per Acre—Bu.	350 or Over		301-349		201-300		100-200		Under 100	
Total Acreage	71. 75		132		284.5		231		42.75	
Number of Farms	6		9		30		22		5	
Acreage per Farm	12		14.7		9.5		11		8.55	
*Ave. Cost per Acre	$127.14		$140.21		$148.89		$127.31		$123.94	
Ave. Yield—Bu.	364		330		251.5		164.9		75.7	
Cost per Bushel	$ .349		$ .425		$ .532		$ .772		$ 1.64	
Seed Cost per Acre	21.1 Bu.	$34.40	20.4 Bu.	$48.82	20.6 Bu.	$42.50	20.8 Bu.	$35.52	22.1 Bu.	$35.12
Manure Cost	2.9 T	$ 3.00	10 T	$10.42	9.9 T	$ 9.82	6 T	$ 6.29	9.9 T	$11 29
Fertilizer Cost	1360 lbs.	$21.25	820 lbs.	$11.62	881 lbs.	$13.52	915 lbs.	$13.15	931 lbs.	$12.04
Green Manure Cost		$13.15		$4.55		$ 3.75		$ 4.66		$ 9.71
Total Fertilizer Cost		$37.40		$26.49		$27.09		$24.10		$33.04
Labor	Hrs.	Dols.	Hrs.	Dols.	Hrs.	Dols.	Hrs.	Dols.	Hrs.	Dols.
Man	63.2	$23.63	70.3	$26.62	93.6	$33.42	65.7	$26.13	49.6	$21.13
Horse	51.9	$ 8.57	53.0	$ 9.98	77.6	$13.67	64.9	$13.08	41.2	$ 8.71
Tractor	1.6	$ 2.47	3.6	$ 5.32	3.3	$ 4.54	3.8	$ 3.80	3.	$ 4.60
*Total Labor Cost		$34.67		$41.92		$51.63		$43.01		$34.44
Spray Material	9.7**	$ 7.57	7.8**	$ 7.10	8.6**	$ 8.62	7**	$ 6.61	5.6**	$ 3.62
Use of Land		$ 6.92		$ 9.60		$ 9.74		$10.17		$10.66
Use of Machinery		$ 3.13		$ 3.32		$ 4.66		$ 3.90		$ 2.69
Sprayer Depreciation		$ 3.05		$ 2.96		$ 4.65		$ 4.00		$ 4.37

*Labor and other costs of grading and marketing were not included in this summary. Some growers sold direct from the field or barn without grading or marketing cost, so that comparable figures could not be obtained on all farms.

**Indicates the number of times sprayed.

LARGE GROWERS MORE EFFICIENT WITH LABOR

TABLE IV.—Variation in Hours of Labor and Labor Costs per Acre in 1928.

	Potato Acreage		
	Over 10 Acres	6-10 Acres	Under 6 Acres
Number of growers*	20	25	22
Man labor, hours	68.7	74.1	81.4
Horse labor, hours	53.3	78.3	64.6
Tractor labor, hours	3.8	2.2	2.8
Total labor cost	$43.84	$48.60	$49.78

*Five growers submitted costs on a part of their acreage and were omitted from this table.

The total labor cost was $5.94 or 13.5 per cent higher on the farms with acreage under 6 in comparison with the group over 10 acres. The same rate was used for all, $.40, $.20 and $1.50 per hour for man, horse and tractor labor respectively.

FACTS ABOUT THE LOW COST GROWERS IN 1928

There were 26 of the growers with costs under 50 cents and averaging 41 cents per bushel. Their average yield was 310.0 bushels per acre and their cost $127.35 per acre.

Twenty of these growers applied manure, six used no manure on their crop. The fertility cost per acre was $29.47 per acre without manure, and $25.98 with manure.

Twelve growers used a green manure crop, fourteen used none. The average application of fertilizer was 956 pounds per acre.

Six growers used all certified seed, eleven used some certified seed, the other nine used home grown seed generally one or two years from certification.

Their fields were sprayed nine times in comparison with eight for the average of the 72 growers.

These 72 growers were far above the average in Ohio, as shown by their yield of 239.5 bushels per acre. Yield per acre was the controlling factor in determining costs. Some growers

had low yields in spite of good seed and good cultural methods because of an unfavorable season for potatoes grown on the heavier type of soils.

METHODS OF COMPUTING GROWING COSTS OF POTATOES

In computing the costs of growing potatoes as shown in this study, these methods were used. ***Cost of seed*** was either the purchase price or the value put on home grown seed by the grower. ***Manure*** in most cases was charged to the crop at one dollar per load for the share of the fertility the potato crop received. ***Seventy per cent of the cash cost of fertilizer*** was placed against the potato crop. ***Green manure crops*** were charged on the basis of estimated dry tonnage per acre at a rate of $3.50 to $6.00 per ton for the share the potato crop used. A sod or stubble plowed under was charged at $1.00 per acre for its manure value. ***Rates on man and horse labor*** were set by the grower and were in most cases either 40 and 20 or 30 and 15 cents per hour respectively. ***The rate for tractor labor*** was generally $1.50 per hour, although in a few instances, the charge was $2.00 or $2.50 where plowing or fitting was hired done, but the extra charge included the labor of the operator of the tractor. The different rates of labor were fairly evenly distributed between the different groups made in the Table III.

Spray material was charged at actual cost per 100 gallons of spray or per pound of dust used. ***The charge for use of land*** was 6 per cent of the value placed on the land by the grower. ***The use of machinery*** was figured at a rate of 6 cents for each hour of horse labor. The rate per hour for tractor labor covered the use of both tractor and tillage machinery. ***The charge for depreciation of the sprayer*** was based on the estimated length of life of the implement according to the number of acres sprayed. The opinion of the growers was that 6 cents per horse hour was not sufficient to cover all sprayer charges.

In a few instances where potatoes were grown in a two-year rotation, following green manure crops the previous year, the total cost of fertilizer, manure, and green manure was charged against the potato crop. In several records where soybeans were grown for green manure the previous year, the cost of seed, labor, and use of land for the additional year, were used as the green manure charge.

Labor of grading and marketing was not included in these costs as this record was available from only a small number of the farms.

Crop and Market News

Prices Tending Downward

(Contributed from the Bureau of Agricultural Economics)

Condition of the early potato crop in 10 southern states was 74% on May 1, declining slightly during April as a result of exceptionally dry weather. The condition of the crop on the same date last year was 78% and in 1928 about 76% of normal. The commercial early crop, which includes about one-third of the total early potato acreage in these states, shows a trifle better condition than the general farm crop but has been quite generally affected by lack of rainfall during April. Continuation of dry weather may materially alter present yield prospects on the commercial acreage. Expected yields now indicate a commercial early potato crop only about 4% larger than in 1929, although the acreage is 16% larger.

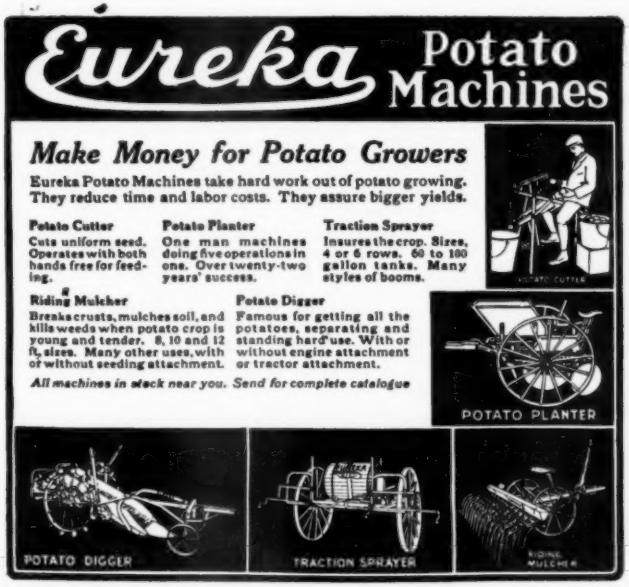
In addition to 150 cars daily from Florida and about 80 each day from the Rio Grande Valley of Texas, early-May movement included 150 cars daily from Alabama and Louisiana together. Shipments quickly became active, especially in Alabama, once the season opened in that section. Total forwardings of new potatoes were approaching 2,000 cars a week, while old potato shipments had decreased to about 2,500 during the seven-day period. New stock should exceed old stock before June. Carolina potatoes will soon dominate eastern markets, as the movement from South Carolina began about May 10 and that from North Carolina was scheduled to start about May 25. Peak movement was past in Florida. The lower valley of Texas also will soon be finished.

Prolonged dry weather was expected to reduce yields of potatoes in many of the early producing areas. Timely rains during May, however, would help the situation materially. Florida reported prospects of about 80 bushels average per acre for this season. Early blight had appeared in many of the fields of South Carolina. One-third of the crop in that state is Green Mountains and the other two-thirds Cobblers. The crop in Georgia was similarly affected by blight. Alabama growers looked for a 25% reduction in average yields from the original prospects for that state. The same kind of reports came from Mississippi. Planting and growing conditions in Missouri have been more favor-

able. The Eagle Lake-Wharton section of Texas showed condition of the crop 78% of normal on May 1. Peak movement from that district was expected by May 20.

The price situation for new potatoes was very favorable during April, with temporary advances in most sections. By May, however, the trend was distinctly downward, although best Florida Spaulding Rose still brought $6 per barrel at shipping points in the Hasting district. Sacked Bliss Triumphs in the lower Rio Grande Valley of Texas had declined to a level of $2.75 per 100 pounds, while the f. o. b. market on Triumphs in Alabama and Louisiana was only $2.50. Terminal prices on Florida Spaulding Rose held rather firmly at $6.75-$8.25 per barrel, but Texas Triumphs were lower at $3.50-$4.50 per 100 pounds, and early arrivals from Alabama sold at $3.25-$4.

The season for old potatoes of the 1929 crop was nearly ended. Because of the rapidly increasing supply of new stock and the inferior quality or condition of many potatoes from storage, prices of old stock tended sharply lower after the end of April. No recent f. o. b. reports have been received from the West, but the northern Maine market on sacked Green Mountains was down to about $2 per 100 pounds, and western New York shippers of


Eureka Potato Machines
Make Money for Potato Growers
Eureka Potato Machines take hard work out of potato growing. They reduce time and labor costs. They assure bigger yields.
Potato Cutter
Cuts uniform seed. Operates with both hands free for feeding.
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One man machines doing five operations in one. Over twenty-two years' success.
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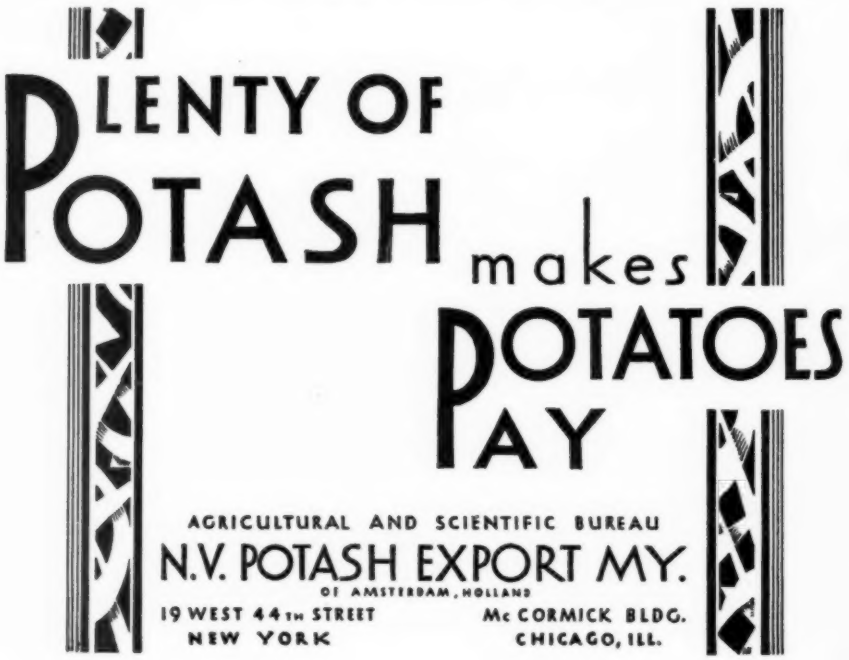
Round Whites were getting $2.60-$2.65, with the North Central f. o. b. range at $2.25-$2.60. These prices, however, were still two to four times those of a year ago. More than half the shipments of old potatoes were originating in Maine, though considerable quantities still came from the North Central States. The Chicago carlot market on northern Round Whites had declined to $2.40-$2.70, with Idaho Russet Burbanks at $3.35-$3.50. Jobbing markets for eastern Round Whites or Green Mountains ruled generally $2.50-$3.65. While the 1929-30 season for late or main-crop potatoes was far better than that of a year ago, the wind-up has been a little disappointing for those who held considerable quantities for the spring market.

Review of Recent Literature

Juzepczuk, S. W. and **Bukasov, S. M.** A contribution to the question of the origin of the potato. Proc. of U. S. S. R. Congress of Genetics. 3:592-611, 1929.

The great abundance of species of the tuber-bearing section of the genus Solanum which occur in Central and South America is pointed out. The authors have established, by what is termed



POTATO GROWER GETS $35.00 PER ACRE EXTRA PROFIT WITH PYROX

Yield Increased 70 Bushels per Acre

After several years experience in spraying with home-made bordeaux and other copper sprays, Mr. C. S. Newcomer is convinced that Pyrox is far superior to any spray he has ever used. He gives other growers the benefit of his experience in the following letter:

This season I made a test comparing Pyrox with home-made bordeaux. Seed, fertilization, cultivation and soil conditions were the same. However my yield on Pyrox sprayed plots was 385 bushels per acre, an increase of 70 bushels over the plots sprayed with home-made bordeaux which yielded only 315 bushels per acre.

While potatoes are selling at a lower price at this time than for several years, the Pyrox-sprayed potatoes will show at least $35.00 more per acre and are more uniform in size, smoother and cleaner in appearance than those sprayed with home-made bordeaux.

Pyrox is easy to use—I need a few minutes to put the material in the spray tank and I am ready to spray. There is no nozzle trouble. Pyrox stays on the vines through hardest rains (this season was exceptionally wet), and goes farther. Because of its soft, smooth, creamy fineness, Pyrox will go through small holes in the nozzle disc, resulting in greater ease in developing and maintaining pressure.

Chambersburg, Pa. (Signed) C. S. Newcomer, Nov. 1, 1928.

Mr. George S. Ranck of New Holland, Pa., was challenged to make a test of Pyrox in comparison with bordeaux.

The results of this test showed that the acre of potatoes sprayed with Pyrox yielded 53 bushels more than the acre sprayed with bordeaux. The growing vines sprayed with Pyrox showed a shade darker green. The fine Pyrox spray gave better protection against blight Mr. Ranck says:

"Better protection, increased yields per acre, and lower costs of production all help to make greater profits."

Many such records as these are on file in the office of the Bowker Chemical Company. They give facts, not claims. These growers know it pays them in extra profits to use Pyrox. Ask your dealer for the new Pyrox Spray Guide or write us direct.

The potatoes shown here by G. S. Ranck were grown on a field sprayed with Pyrox.

Pyrox

Kills Bugs

Prevents Blight

Increases Yields

Bowker Chemical Company

419 Fourth Ave.

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the "differential-geographical" method, two centers of origin of the potato, viz., the Peru-Bolivian plateau and Southern Chile, including the island of Chiloe and adjoining islands. It is not believed that the progenitor of the cultivated varieties can be recognized at the present time. It is considered probable that primitive man brought under cultivation many forms and that the products of the hybridization of these forms make up the so-called species known as Solanum tuberosum. The subdivision of the present collective S. Tuberosum into a series of species corresponding in scope to the world species is deemed logical.

—C. F. CLARK.

Rybin, V. A. Karyological investigations on some wild growing and indigenous cultivated potatoes of America. Bul. Appl. Bot., Genetics and Plant Breeding, 20:655-720, illus. 1929.

The investigator concludes from his colleague's studies of the chromosomes of the potato and his own study of six selected varieties that all European and North American commercial varieties probably have 48 as their somatic chromosome number. In the forms of wild potatoes investigated it was found that **Solanum muricatum** Ait, **S. chacoense** Bitt., **S. Jamesii** Torr, **S. Bukasovii** Juz. n. sp., **S. aracc-papa** Juz. n. sp., have 24 as their somatic chromosome number; **S. colombianum** Dun. var. **Trianae** Bitt. n. f., S. **palustre** Poepp., **S. acaule** Bitt, var. **subexinterruptum** Bitt., **S. Antipovichi** Bukasov, **S. Fendleri** Gray, and S. **ajuscoense** Bukasov, have 48 as their somatic chromosome number; the following forms of **S. demissum,—recurvoacuminatum, longibaccatum, xitlense, tlaxpehualcoense** and **adpressoacuminatum,**—have 72 as their somatic chromosome number; **S. Commersonii** Dun., **S. coyoacanum** Bukasov n. sp., **S. medians Bitt,** have 36 as their somatic chromosome number; and **S. demissum** (not typical), **S. demissum** x **Majestic** and **S. edinesne** Berth, have 60 as their somatic chromosome number. The forms with 36 and 60 chromosomes were known either to be hybrids or had morphological or cytological characters that suggested a hybrid ancestry. The 236 specimens of the cultivated potato collected in Central and South America were found to have either 24, 36, or 48 as their somatic chromosome numbers. All forms with 36 chromosomes had morphological characters of a meiotic behavior at the time of pollen formation that led to the conclusion that they are hybrids originating either from a cross of cultivated species with 24 and 48 chromosomes or descended from 36-chromosome wild forms. The cytological data presented is weighty confirmation of the supposition that cultivated potatoes have a polyphyletic origin.

—A. E. LONGLEY.